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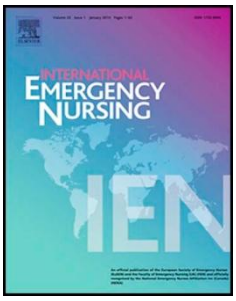

Title: Developing situation awareness amongst nursing and paramedicine students utilizing eye tracking technology and video debriefing techniques: a proof of concept paper

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Title

Developing situation awareness amongst nursing and paramedicine students utilizing eye tracking technology and video debriefing techniques: A proof of concept paper

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Highlights

- High-level situational awareness can be improved through simulation.
- Participants' post-course ratings of their skills, competence and confidence improved.
- Eye tracking and point of view recording techniques can benefit performance.
- Participants placed a high value on the video debriefing.
- Visual field review techniques may enhance the use of realistic simulated practice.

Abstract

Objective

The aims of this quasi-experimental before-and-after study were to first determine whether the use of eye tracking technology combined with video debriefing techniques has the potential to improve the quality of feedback and enhance situation awareness (SA) in simulated settings and second to determine students' satisfaction towards simulated learning.

Methods

Nursing and paramedicine students from three universities participated in three 8-minute simulation scenarios of acutely deteriorating patients. Eye tracking glasses video recorded the scenarios and tracked right eye movement. On completion, participants were questioned using the Situation Awareness Global Assessment Technique, completed the Satisfaction with Simulation Experience Scale (SSES), and provided textual feedback and received video-based verbal feedback.

Results

Participants lacked awareness of presenting medical conditions and patient environments and had poor recall of patient vital signs. Significant improvements in SA scores were demonstrated between the first and third scenarios (p=0.04). Participants reported greater insight into their performance and were satisfied with simulated learning.

Conclusions

Use of visual field review techniques appears to enhance the use of realistic simulated practice as a means of addressing significant performance deficits. Eye tracking and point of view recording techniques are feasible and with applicable debriefing techniques could enhance clinical and situated performance.

Keywords: Paramedics; Nurses; Patient simulation; Decision making; Situational awareness; Performance deficits

TITLE

Developing situation awareness amongst nursing and paramedicine students utilizing eye tracking technology and video debriefing techniques: A proof of concept paper

INTRODUCTION

Background

Non-technical skills such as decision-making and situation awareness are explicitly addressed in the aviation industry, but the healthcare industry continues to lag behind even though they are essential for quality of care and patient safety (Vickers, 2007). Situation awareness (SA) is a cognitive process that involves perceiving and comprehending critical elements of information during a specific task (Saus *et al*., 2010). High-level SA is crucial for nursing and paramedicine undergraduates who will be required to make potentially life-saving decisions in complex, unpredictable and demanding situations (Williams *et al*., 2013).

The theoretical support for a simulation-based educational approach is that non-technical skills necessary for practice are best acquired through situated learning, an approach supported by experiential learning theory (Lave & Wenger, 1991; Lisko, 2010), and of abstract conceptualization and concrete experience. In addition, modalities of learning such as physical (or kinesthetic), visual, visual/verbal, and auditory have been described (Kolb, 2005) and demand varied teaching approaches to meet students' diverse learning styles. Models of formative assessment *for* and *as* learning provide students with opportunities to reflect on their practice and receive constructive and timely feedback. Summative assessment, such as objective structured

clinical examinations (OSCEs), are valuable to learning but may lack the benefits of structured feedback (Rudolph *et al*., 2008; Tiwari *et al*., 2005).

Debriefing as formative assessment has underpinnings in cognitive science, social psychology, and anthropology, and contributes to how people perceive reality (Rudolph *et al*., 2008). People construct cognitive "frames" enabling them to make sense of their environment. These frames contribute to students' performance in clinical scenarios, where an objective is to identify a performance gap and to assist students to narrow or eliminate that gap. Video debriefing promotes self-evaluation of actions and clinical skills and stimulates learning through discussion (Grant *et al*., 2010; Hays, 1990; Paul *et al*., 1998). It allows learners to build on past experiences through critical reflection and active involvement transforming the learner's experiences and developing knowledge(Vigeant *et al*., 2008). Comparisons of video debriefing with oral debriefing raise some doubt about the effectiveness of this approach to clinical teaching (Grant *et al*., 2010; Nilsen & Baerheim, 2005). Central and unique to this study was the use of eye tracking technology; Tobii Eye Tracking Glasses™ incorporating a video camera and overlays of right eye movement.

Importance

While simulation techniques and OSCEs, either separately or in combination, can be used to measure non-technical skills such as SA, issues arise. Feedback is often limited as video recorded debriefings of OSCEs are time consuming, SA is not isolated and captured, and feedback, although essential for learning, is often reported as inadequate (Cant & Cooper, 2011).

Eye tracking devices have never been used in the emergency education setting and this simulation-based research will inform education and practice and has the potential to enhance clinical practice. For example, relatively inexpensive 'point of view' cameras (without eye tracking) are now available and could be used to record resuscitation events, evaluate performance and enable team debriefing.

Goals of this investigation

This project addresses the challenge of limited time using an innovative combination of techniques, namely video recording, eye tracking and visual field review (video feedback) to understand and inform participants' responses to acutely deteriorating patients.

The primary aim of this study was to determine whether the use of eye tracking technology combined with visual field review techniques has potential to improve the quality of feedback and enhance SA in students undertaking simulated emergency training. A secondary aim was to determine students' satisfaction toward simulated learning.

METHODS

Study design and setting

Final year nursing and paramedicine students who were near programme completion were invited to participate in this quasi-experimental before-and-after study focusing on SA during the management of 'deteriorating patients'.

Selection of participants

Owing to the preliminary nature of the study and finite resources, convenience sample was used, comprising 40 students: 20 from University A and 10 each from University B and University C. Participation in the study formed part of students' normal weekly simulation practice, thereby not disrupting or adding to students' workload. Institutional ethics committee approvals were gained from the participating universities: Monash University CF13/652 – 2013000282, La Trobe University FHEC13/059; University of Queensland 2013000405.

Interventions

Participants completed three 8-minute clinical scenarios in which they were required to assess and treat deteriorating patients suffering acute myocardial infarction, shock, and chronic obstructive pulmonary disease respectively. They were provided with standard equipment and a junior partner to follow direction and assist them. Between each scenario trained facilitators conducted a 20 minute debriefing session utilizing the eye tracking vision. In addition to encountering a different patient condition in subsequent scenarios the global scene was changed slightly in each scenario to further test their SA.

Methods and measurements

Using trained actors (simulated patients) participants completed the clinical simulations and underwent video debriefing after each session (Figure 1). On completion of each scenario participants were asked a series of questions using the Situation Awareness Global Assessment Technique (SAGAT) (Endsley, 1995), which enabled quantitative ratings of SA (Endsley, 1988). The SAGAT situation awareness tool incorporated four subscales: physiological perception; global situation perception; comprehension; and projection. On completion of the three scenarios participants self-rated their perceived

ability to recognize a deteriorating patient, manage emergency priorities and perform emergency tasks as well as their overall confidence and competence levels.

Insert Figure 1 here

The debriefing process had three phases: a reactions phase, where the participant was able to "blow off" steam and the debriefer observed and evaluated the participant's emotional and psychological state; an analysis phase, where the debriefer and the participant engaged in a reflective process of analysis and learning; and a summative phase, where the lessons learned were placed in context and a plan for narrowing the performance gap developed to improve future performance (Rudolph *et al*., 2008).

Participants completed the Satisfaction with Simulation Experience Scale (SESS), assessment of their clinical confidence and competence, and a general course evaluation. The SSES is an 18 item survey measuring satisfaction on a five point Likert scale (1=strongly disagree to 5=strongly agree) and is defined by three factors: debrief and reflection, clinical reasoning, and clinical learning (Levett-Jones *et al*., 2011).

They completed a course evaluation survey which was based upon a seven item survey on a five point Likert scale (1=strongly disagree to 5=strongly agree) followed by three open ended questions. The questions included: What were the key things you learnt from this programme? How could this programme be improved? What were the benefits of eye tracking during clinical simulation? The participants also rated the impact of the

eye tracking techniques on a three item survey using a five point Likert scale: 'not at all' (1), "to a large extent (5).

Participants' focus of attention was tracked using Tobii™ Eye Tracking Glasses that tracked right eye movement and focus of attention through a reflective light technique and recorded all data in a belt-mounted data pack. Data was uploaded to a computer for visual replay and debriefing with consideration of participants' focus (or over-focus) of attention.

Formative assessment was achieved through the use of photo elicitation (video reflective review) (Goff *et al*., 2013). When drawn together in a feedback session the eye tracking technology, SAGAT measures and photo elicitation were intended to assist participants to reflect upon and improve their performance.

Outcomes and analysis

The Tobii™ Eye Tracking technology was used to identify participants' area of interest, gaze fixation/duration, and scan path. This enabled analysis of where they were looking when a decision was made. Based upon the 'eye mind hypothesis' the assumption was that gaze fixation is normally the focus of thought (Duchowski, 2007).

Statistical software (IBM-SPSS V 20) was used for data storage and tabulation of the quantitative data. The effect sizes (d) were calculated to evaluate the findings and a p value of <0.05 considered statistically significant. A combination of parametric and non-parametric statistics was used for comparative analyses.

Trained facilitators debriefed individual participants using the eye tracking recordings to inform their level of SA and clinical performance. A standard photo elicitation schedule

was used for each scenario to ensure consistency between facilitators (Goff *et al*., 2013). On completion of the three simulations and facilitator feedback participants completed an evaluation questionnaire that invited textual responses describing their overall experience.

RESULTS

Characteristics of study subjects

Thirty-nine final year students studying nursing and paramedicine from three universities in three Australian States participated in this study (Table 1). One volunteer student failed to attend on the day of the study.

Insert Table 1 here

Nursing students were enrolled in three-year Bachelor of Nursing degrees. Paramedicine students were enrolled in either a three-year Bachelor of Emergency Health or four-year combined degree, Bachelor of Health Science/Master Paramedic Practice. This latter group were in the fourth year of their course while the remainder were in the third year and all met the inclusion criteria of 'near completion' students. All but three international students spoke fluent English.

Seventy-four percent of participants were female with a median age of 21 years (range: 19 - 53 years M: 26.5 years, SD = 9 years). There was no significant age difference between the nursing and paramedicine groups ($p = 0.31$).

Participants had completed clinical placements in general hospital wards, mental health settings, aged care institutions, community health or paramedic services. Over one-third of the participants (n = 15; 38.5%) reported prior employment in healthcare related fields. Almost two-thirds (n = 23; 59%) reported witnessing a patient deteriorating, but none had played an active role in patient management.

Main results

Situation awareness

Participant SA scores were moderate overall with an average score of 52%. The results in Table 2 suggest that they lacked awareness of the presenting medical condition and the patient's environment. Participants could not recall the patient's vital signs, although they were able to anticipate further deterioration.

Insert Table 2 here

There was progressive improvement (statistically non-significant) between each scenario and a significant improvement between the first (Cardiac scenario) and the last scenario (Respiratory scenario) (t = -2.08, df = 38, CI -1.21 to -0.02; p = 0.04. MD = 0.59). The key result was significant improvement in SA scores between the first and third scenarios with a small effect size (Cohen's d = -0.40; r = 0.20).

Improvement in SA scores over the course of the three scenarios was explored by discipline with paramedicine students' SA scores showing a trend of improvement approaching significance between the first and third scenarios (n =19: Z = -1.88, p =

0.059). There was some evidence of paramedicine students achieving higher SA scores than nursing students, with significantly higher scores evident in the final scenario. Mann-Whitney U tests revealed comparatively higher paramedicine student SA scores in the respiratory scenario (M PM 7.00, BN 5.35; $p = 0.009$).

When the four SA subscales were examined individually over the three consecutive scenarios, average awareness ratings for the first three subscales were all low: 40%, 31%, and 49% respectively. Overall participants scored better in terms of projection or forecasting the likely medical consequences with a SA 'projection' rating of 75%, although this did not improve with experience.

Eye-tracking

When participants were asked to rate whether the use of eye-tracking equipment aided feedback 35 (90%) agreed, rating this highly on a five point scale (4 or 5; M 4.46 SD 0.76). Participants were asked to rate whether eye-tracking equipment improved their learning, with 34 (87%) rating this highly (4 or 5; M 4.38 SD 0.78). The key result was that nearly all felt 'eye-tracking' improved learning and aided feedback. When asked whether they benefited from using the eye-tracking equipment, all but one participant agreed.

Satisfaction with Simulation Experience

Participants reported a strong satisfaction with the simulated learning programme, rating 18 of the SSES ≥4.51 of five points. A full distribution of items results can be found in Table 3.The most positively rated items were: 'The facilitator made me feel comfortable and at ease during the debriefing' (M=4.97; SD=0.16); 'I had the opportunity to reflect

on and discuss my performance during the debriefing (M=4.90; SD=0.38) and 'Reflecting on and discussing the simulation enhanced my learning' (M=4.90; SD=0.31). A Mann-Whitney U test revealed significantly higher total scores in the nursing group than in the paramedicine group ($Z = -2.546$, $p = 0.011$). There were significant differences by discipline in clinical reflection ($p = 0.006$) and clinical learning ($p = 0.010$) with a trend of difference not reaching significance in debrief and reflection ($p = 0.66$). In each case the nursing group rated the simulation experiences more highly than the paramedic group.

Insert Table 3 here

Qualitative feedback

Participants reported in their text responses that they benefited from the video and audio playback, but not necessarily on the eye-tracking component itself.

> "The video and feedback was more useful than the actual eye tracking". (Nursing)

They placed a high value on the video debriefing and the attention focus component as it created an opportunity to reflect on areas of interest. Participants found the feedback to be an essential component of the learning activity and likely to develop their clinical decision-making competencies.

"… the first few scenarios showed me where I wasn't looking and focused me to where I need to for the future. It was interesting as well just to see where I look in deteriorating situations". (Nursing)

"Immediate reflection on my clinical reasoning assessment and treatment of the patient and what should be done better next [helped]. To reflect straight after was perfect". (Paramedicine)

DISCUSSION

The results from using the SAGAT suggest that study participants lacked awareness of the presenting medical condition and the patient's environment. They often failed to recall the patient's vital signs, although they were able to anticipate further deterioration in the patient condition. This suggests a need for repetitive practice in high fidelity situations to enhance SA. The other results demonstrate positive feedback from learners using eye tracking technology and video debriefing and support the body of knowledge around video debriefing that it enables learners to transform experience into enhanced knowledge and skills.

Participants reported a greater insight into their performance and the possible positive impacts on practice. They placed a high value on video debriefing and claimed to benefit from the reflection on their attention focus. Paramedicine students performed better than nursing students in these particular scenarios; this difference could be associated with paramedics' greater expectation of dealing with deteriorating patients (Williams *et al*., 2013), or it may have been that nurses have a wider range of skills that they could potentially call upon.

Participants from both disciplines reported that eye tracking enhanced the experience of video debriefing and did not detract from the simulation scenario experience. However, the full extent to which eye tracking technologies are beneficial remains unclear. Outside of the research environment there are often limitations that impact on the feasibility of these approaches on a regular basis (Cant & Cooper, 2011). Debriefing involving more than one student takes 45-60 minutes and for individual debriefing an appropriate amount of time needs to be set aside to achieve the goals of the session and the simulated learning activity (Rudolph *et al*., 2008).

Feedback is the key to acquiring clinical skills; it provides insights and highlights dissonance between intended and acquired results (Ende, 1983; Vigeant *et al*., 2008). Video debriefing allows learners to review their clinical skills practice, reflect on their performance and receive feedback. The use of video and eye tracking allows the learner to pinpoint their area of interest at the time a decision is made, promoting clinical decision making reflection based upon the eye-mind hypothesis (Poole & Ball, 2006).

Feedback on the impact of the eye-tracking equipment was positive, with many students stating they benefited from the technology. Conversely, there were comments suggesting that video debriefing was more beneficial than the actual eye tracking.

Use of visual field review in this study appears to have enhanced the use of realistic simulated practice as a means of addressing significant performance deficits. Participant SA did improve significantly. The findings suggest that use of this combination of eye tracking and video feedback may improve nursing and paramedicine students' awareness of presenting medical conditions and the patient's environment. This is consistent with a number of nursing education studies (Cant & Cooper, 2011; Kinsman

et al., 2012). Further research is needed to access the effectiveness of eye tracking as an educational tool and the cost benefit analysis.

Eye tracking and point of view recording techniques are feasible and with applicable debriefing techniques benefit clinical and situated performance. Repetitive and frequent high fidelity simulation may reduce the time it takes for students to reach competency. These findings support the view that significant performance deficits can be addressed by realistic simulated practice and the positive results from the SSES suggest that authentic learning opportunities are achievable with appropriate feedback and debriefing.

Some evidence suggests that oral and video debriefing approaches are of equivalent benefit (Savoldelli *et al*., 2006), however our findings confirm the benefit of video debriefing demonstrated by others (Hamilton *et al*., 2012; Scherer *et al*., 2003). It is postulated that video aligns the learner's perception of performance with actual performance, highlighting any discrepancies and in turn increasing motivation for improvement, with possible long term impacts (Scherer *et al*., 2003).

Eye tracking and point of view recording techniques are feasible and, with appropriate debriefing techniques, benefit clinical and situated performance. However, the proof of concept pilot was resource intensive, requiring three to four academics and one simulated patient to 'train' five students per day. As a stand-alone training programme this is unlikely to be feasible for most educational providers. It would be beneficial to consider less resource rich approaches by combining point of view recordings and video feedback, in team-based scenarios with student self-review.

LIMITATIONS

Funding for the study was finite and the simulation scenario exercises are resource intensive. As a result the study design was a pragmatic pilot and included relatively small numbers of participants. We were unable to compare the characteristics of participants with the larger student cohorts primarily because some of the characteristics of interest are not routinely collected.

Volunteer bias may have influenced recruitment, but it would be speculation to presume that volunteer students were more or less competent or confident. The direction of effect of this potential threat to external validity is impossible to predict. A restriction to participation in the study was that those who wore glasses to correct vision could not participate, unless they were able to remove corrective lenses.

Conducting the study over three sites posed a threat to internal validity and to minimise this risk a core team of researchers travelled to each site to enable consistency to the extent possible and reduced potential measurement error. Calibration of the Tobii™ glasses between each scenario requires trained personnel, so that the accuracy of eye tracking and gap between scenarios is consistent. Calibration was easier in participants with blue eyes.

Conclusions

In this proof of concept study visual field review techniques appear to enhance the realistic simulated practice as a means of addressing significant performance deficits. Eye tracking and point of view recording techniques are feasible and with applicable debriefing techniques benefit clinical and situated performance. There remain questions as to whether this teaching approach has a sustained impact within the clinical arena.

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Figure 1.

Table 1 Study Participants

	University A	**University B**	**University C**	**Totals**
Nursing	10	10	0	20
Paramedicine	10	0	9	19
Totals	20	10	9	39

Table 2 Total SA scores for each scenario in order of completion (n = 39)

	Cardiac scenario	**Shock scenario**	**Respiratory Scenario**
Mean	5.54 (SD 1.52)	5.61 (SD 2.03)	6.15 (SD 1.93)
Median	5	5	6
Score range	3-9	2-10	3-11
Percentage score	50.3%	51.0%	55.9%

Table 3 Satisfaction rating according to the SSES (n=39)

Item	**Mean**	**SD**

1.	The facilitator provided constructive criticism during the debriefing	4.87	0.34
2.	The facilitator summarised important issues during the debriefing	4.85	0.37
3.	I had the opportunity to reflect on and discuss my performance during the debriefing	4.90	0.38
4.	The debriefing provided an opportunity to ask questions	4.82	0.39
5.	The facilitator provided feedback that helped me to develop my clinical reasoning skills	4.87	0.34
6.	Reflecting on and discussing the simulation enhanced my learning	4.90	0.31
7.	The facilitator's questions helped me to learn	4.79	0.47
8.	I received feedback during the debriefing that helped me to learn	4.87	0.39
9.	The facilitator made me feel comfortable and at ease during the debriefing	4.97	0.16
10.	The simulation developed my clinical reasoning skills	4.62	0.54
11.	The simulation developed my clinical decision making ability	4.54	0.41
12.	The simulation enabled me to demonstrate my clinical reasoning skills	4.51	0.51
13.	The simulation helped me to recognise patient deterioration early	4.49	0.68
14.	This was a valuable learning experience	4.97	0.16
15.	The simulation caused me to reflect on my clinical ability	4.79	0.41
16.	The simulation tested my clinical ability	4.79	0.41
17.	The simulation helped me to apply what I learned from the case study	4.61	0.60
18.	The simulation helped me to recognise my clinical strengths and weaknesses	4.82	0.39

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